The LANL Physical Inventory Program

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-ABSTRACT-

OVERVIEW:

The LANL physical inventory program (statistically based) provides assurance that the inventory is represented to the defined confidence levels. In addition, it establishes a benchmark to prove that the inventory is accurately stated.

DESCRIPTION:

The LANL's Physical Inventory Program for nuclear materials requires the performance of periodic physical inventories and special inventories of nuclear material. The Inventory Program also requires the reconciliation of inventory measurements with previously established nuclear material accountability values. This inventory program applies to all material balance areas (MBAs) and is designed in accordance with DOE order 474.1, "Nuclear Material Control and Accountability". The program uses a graded approach for performing physical inventories with primary emphasis placed on Categories I and II quantities of special nuclear material. This paper describes the essential elements of the LANL Physical Inventory Program. In addition, the inter-dependency of the Inventory Program with respect to other LANL MC&A Programs is discussed. This paper, by outlining the elements and approach of a site-specific physical inventory program assists safeguards practitioners in the design of related physical inventory programs.

-END OF ABSTRACT-

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INTRODUCTION:

REQUIREMENT:

- DOE Order 474.1-1.
- LANL Material Control and Accountability (MC&A) Plan.

Policy:

DOE requires periodic physical inventories to verify the effectiveness of physical security systems, validate the materials accountability book values and records, and provide assurance that nuclear materials are in authorized locations and present in their purported quantities. Inventories are standard accounting and quality control assurance measures for systems designed to protect nuclear material in all MBAs. DOE O 474.1 allows the use of alternative control mechanisms to reduce the frequency of physical inventories. Alternative measures may include procedures, approaches, controls, and technologies that maintain safeguards assurance equivalent to the inventory frequencies required by DOE M 474.1-1 but without the use of as many inventories

DEFINITIONS:

LANL Material Control and Accountability Plan	The LANL Material Control and Accountability Plan is LANL's official document and intent for meeting the current specified DOE Order 474.1
Graded Safeguards[1]	A system designed to provide varying degrees of physical protection, accountability, and control to different quantity and type of special nuclear material. The more attractive the material is to diversion acts the more stringent the controls.
The LANL MASS Data Base	Materials Accounting Safeguard System (MASS) is the official Accounting system used to track and account for Nuclear Materials at LANL. Specific training and authorizations are required before anyone can obtain any Nuclear Material.
Special Nuclear Materials that DOE accounts for	Nuclear Material Accounting-Doe Orders require the accounting and tracking of the following Special Nuclear Materials: Uranium, Plutonium, Americium, and Neptunium-237. Other tracked nuclear materials are: Berkelium, Californium, Curium, Deuterium, Lithium-6, Thorium and Tritium.
Population	Population size with respect to sampling.
Sample Size	Number of items sampled from population.
Material Balance Area (MBA)[2]	An area that is both a subsidiary account of materials at a facility and a geographical area with defined boundaries, used to identify the location and quantity of nuclear materials in the facility.
Categories of Special Nuclear Material (Categories I, II, III and IV) [2]	A designation determined by both the quantity and type of Special Nuclear Material or of a Special Nuclear Material location based on the type and form of the material and the amount of material present. [see Nuclear Materials Category and DOE M 474.1] A designation of significance of special nuclear material that is based upon the material type(s), the form(s) of the material, and the amount of material present in an item, grouping of items, or in a location.

Attractiveness Level[2]	A categorization of nuclear material types and compositions that reflects the relative ease of processing and handling required to convert that material to a nuclear explosive device.
LANL Accountability Measurement	A quantitative measurement using an approved non-destructive assay (NDA) or destructive assay (DA) techniques for determining nuclear material content and are the basis for establishing or changing a book value.
LANL Verification Measurement	A quantitative measurement using approved non-destructive assay (NDA) or destructive assay (DA) techniques to verify an existing accountability value.

Physical inventories for special nuclear materials must be performed at least as often as the frequencies specified in the table below:

DOE M 474.1-1 Table V-1, Minimum Inventory Frequencies

MBA	MATERIAL	MINIMUM FREQUENCY
Category I or II (processing area)	Special Nuclear Material	Bimonthly[3] or End of Campaign
Category I or II (storage area)	Special Nuclear Material	Semiannually
Category I or II	Substitutable[4] Material	(same as special nuclear material)
Category I or II	Nonsubstitutable Material	Biennially
Category III or IV	All nuclear materials	Biennially

Statistical Sampling Plan:

The physical inventory statistical sampling procedure is an alternative approach to a 100% physical inventory; the procedure provides confidence that items on the accounting records are locatable and that they contain the amount of nuclear material specified in the records. The conclusions drawn from the sample inventory items are used to make statements or inferences about the state of the entire population. This sampling plan emphasizes items with larger quantities of SNM and materials more attractive to theft and diversion scenarios. Within the population of NM items, the

larger-gram items of SNM are sampled at a higher rate than smaller-gram SNM items or NM items, and within material category levels, the more attractive materials are sampled at a higher rate than less attractive materials.

Sampling Objectives

Verifying a physical inventory using a sample of inventory items achieves three objectives:

- the items on the accounting records are locatable,
- the items contain the amount of nuclear material specified in the records, and
- items adjacent to the items in the sample are present in the inventory records.

- These objectives are satisfied by applying a statistical statement about the entire physical inventory population. The minimum sample size selected from each physical inventory population allows LANL to make a statistical statement[5] that at least 97% of the items are without defect at a 95% confidence level for all category levels. An additional 10% of randomly selected items are chosen to meet the minimum requirement for a 95% confidence level that 97% of the items have no problems assuming "zero" defects were found.

Also, the Statistical Sciences Group D-1 formerly TSA-1:

- Provides S-4 with MC&A statistical support,
- Computes physical inventory statistical data for S-4, and reports results to the S-4 Technical Support Team.

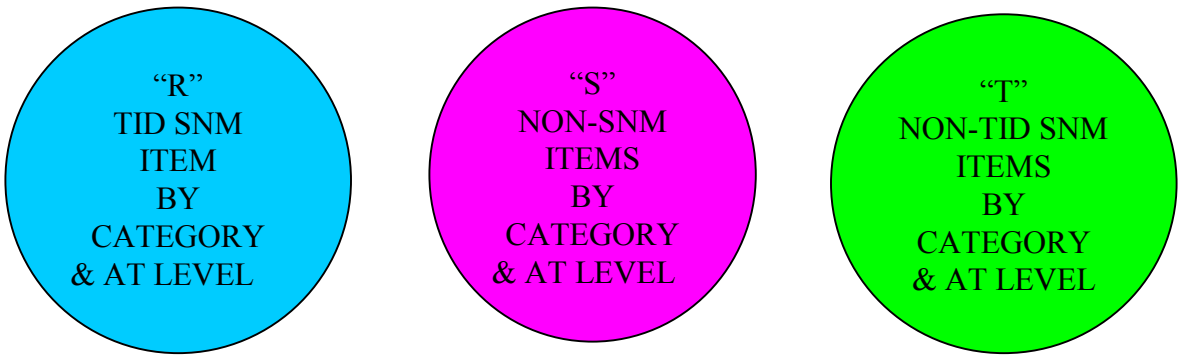
As previously described, the validation of two adjacent items located near the randomly chosen item provides added assurance that the inventory records accurately reflect the physical inventory.

STATISTICAL GOAL:

To randomly select a sample size which will yield a minimum result at the 95/97 percent confidence level assuming "zero" defects (this is discussed later).

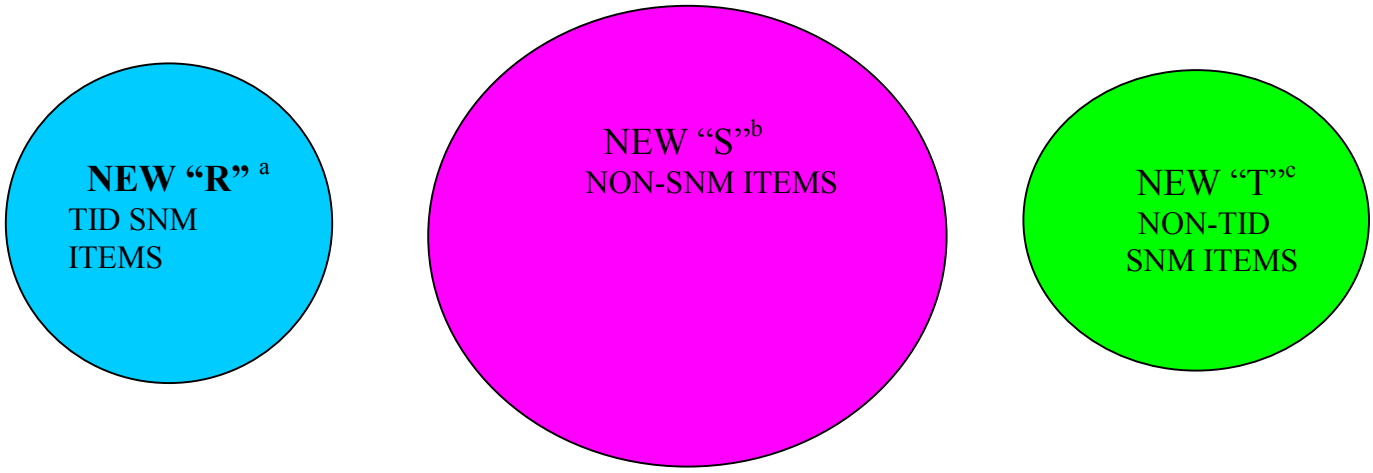
CRITERIA BY CATEGORY AND ATTRACTIVENESS LEVEL:

The population consists of TID'd SNM items/containers, NON-TID'd's SNM items/containers, and NON-SNM items/containers. All are contained within a single population that is stratified by category and attractiveness level.



NEW STRATIFICATION OF SAMPLE SIZE:

The pre-selection sample list is further stratified by graded safeguards[1] as follows.



[a]NEW R = TID SNM ITEMS FOR CAT I, II, III and CAT IV ATTRACTIVENESS B&C ≥ 50 grams.

[b]NEW S = NON-SNM items
PLUS [TID CAT IV B&C SNM items <50 grams, and all TID CAT IV D&E SNM items].
PLUS [NON-TID CAT IV B&C SNM items <50grams, and all NON-TID CAT IV D&E SNM items].

[c]NEW T = NON-TID SNM ITEMS FOR CAT I, II, III and CAT IV attractiveness B&C ≥ 50 grams.

PORPORTIONED WEIGHTED FACTORS:

Each category of items is selected at a specified proportioned weight factor. These proportioned weight factors were developed by a panel of experts following a graded safeguards approach and approved by DOE. The main sampling goal is to ensure sampling of those items of higher attractiveness levels more often than lower attractiveness level items. The entire population is now assigned a random[5] number.

Next, the TID, NON-TID and NON-SNM are given weighted ratios. The NON-TID items are given higher weighted ratios than the TID items and NON-SNM items.

The following criteria will be used by LANL to ensure compliance with DOE O 474.1 Physical Inventory statistical confidence requirements.

- The confidence statement will only pertain to "defects" as currently defined in the MC&A Plan or reference definition page.

- The entire population as defined by the PIO will be sampled at a rate to ensure that a 95/97 confidence statement can be made if "0" defects are found. The sub-strata sample population sizes will be apportioned with the following weighting factors.

The population will be subdivided into nine (9) sub-strata as listed below:

STRATA	STATUS	WEIGHTING[a] FACTOR	STATUS	WEIGHTING[a] FACTOR
CAT I	TID	22	NON-TID	44
CAT II	TID	15	NON-TID	30
CAT III	TID	7	NON-TID	15
CAT IV	TID	2	NON-TID	4
NON-SNM[b]	ALL	1	N/A	N/A

[a]Based on LANL's population, the weighting factors assure that at approximately 31% of the Cat I NON-TID items will be selected, 16% of the Cat I TID'd items will be selected, and less than 1% of the NON-SNM[b] items will be selected.

[b]The NON-SNM strata consists of **all** NON-SNM items,
PLUS TID CAT IV B&C SNM items <50 grams,
PLUS NON-TID CAT IV B&C SNM items <50grams, and all NON-TID CAT IV D&E SNM items.

A small number of alternates will be added to the minimum number of items selected to ensure that the required statistical statement can be made. These alternates are rolled-up into the primaries. The PIO will be supplied the list of alternates and will only issue items to the inventory team(s) on an "as needed" basis.

GENERATION OF SAMPLE SIZE SELECTION:

Next, sample size tables[6] were developed looking at the lower hypergeometric confidence bound for a given total sample size and the number of defective items in the sample.

A sample size at the 95/97 percent assuming "zero" defects is now generated from the population.

CONFIRMATORY AND/OR VERIFICATION MEASUREMENTS:

Floor Items- NON-TID items statistically selected from the floor area for verification measurements are either double confirmed or verified. TID items are confirmed.

Vault Items- Only confirmatory measurements are performed.

ANOMALY RESOLUTION:

The Physical Inventory Officer (PIO) will resolve any physical inventory problems that occur during the inventory process. Conducting a physical inventory may reveal two types of anomalies that are investigated and tracked: defect(s) and discrepancies.

- Defects related to the LANL Physical Inventory are serious anomalies that may indicate that an item is missing or that the quantity of nuclear material in an item has a statistically significant difference. A single defect can cause failure of the statistical sample of the inventory population and the PIQC recommends whether to require additional sampling of the inventory population or a 100% inventory.

- Discrepancies related to the LANL Physical Inventory are anomalies that suggest a potential quality problem with items in inventory; however, they do not by themselves indicate that material has been lost. S-4 records and maintains discrepancies as indicators of MBA performance against MC&A objectives. The PIQC analyzes discrepancies together with information from vulnerability assessments, performance tests, and any other activities that evaluate the way MBAs implement MC&A programs. The PIQC then recommends whether to retain it as a discrepancy or elevate it as a defect status.

Physical Inventory Quality Committee (PIQC)

The PIQC is composed of the PIO, S-4 Group Leader, TST Team Leader, NM Accounting Team Leader, NM Control Team Leader, and the NM user organization line manager or delegate. The PIQC

- responds to physical inventory policy issues,
- develops acceptance/rejection criteria for item controls and verification/confirmation measurements,
- assesses physical inventory results and determines compensatory measures for inventory defects,
- recommends final acceptance of inventory results to the S-4 Group Leader, and
- for any case where there may be evidence of a diversion or theft, the S-4 Group Leader reports the anomaly immediately to DOE/AL. In addition, the PIQC will initiate a special 100% inventory of the affected MBA to determine if other evidence of tampering exists. The PIQC will recommend placing the MBA on hold, disallowing any transfers into or out of the MBA, until the physical inventory is reconciled with the book inventory.

Note: The PIO and at least two other identified PIQC members must be present when the PIQC addresses physical inventory issues.

CONCLUSIONS OF PAPER:

The inventory program ensures that Laboratory's MC&A safeguards measures have been effective by providing an acceptable level of confidence that:

- The randomly selected nuclear materials listed in the MASS database are properly labeled (i.e., MBA, material type, and LotID) and in their authorized locations
- The nuclear material accountability book values are correct within the statistical uncertainties of the measurement methods used
- No accountable nuclear materials are on site that is not recorded in the MASS database (Unless approved documentation permitting material to be written off exists)
- TID program performance is validated
- Accountable nuclear materials are not being diverted or stolen

- The physical inventory audits help to possibly detect diversion of SNM by using higher weighted factors for NON-TID items versus tid-items versus the safeguarded approach.

REFERENCES:

[1]Reference MC&A Plan last printed 9/28/00 (MCAP 1.0 INTRO REV 6.1, page 3) for graded safeguards definition.

[2]Reference the Department of Energy "Safeguards and Security Glossary of Terms" dated December 18, 1995.

[3]Bimonthly here means once every two months.

[4]Substitutable materials are source or other nuclear materials that are collocated with special nuclear material for which they can be credibly substituted as a part of a theft or diversion scenario.

[5]LANL uses the Microsoft excel software random number generator macro to obtain these random numbers.

[6]The reference for the sample size tables is Cochran, William G., Sampling Techniques. John Wiley and Sons, New York, NY, 1977, Page 57.